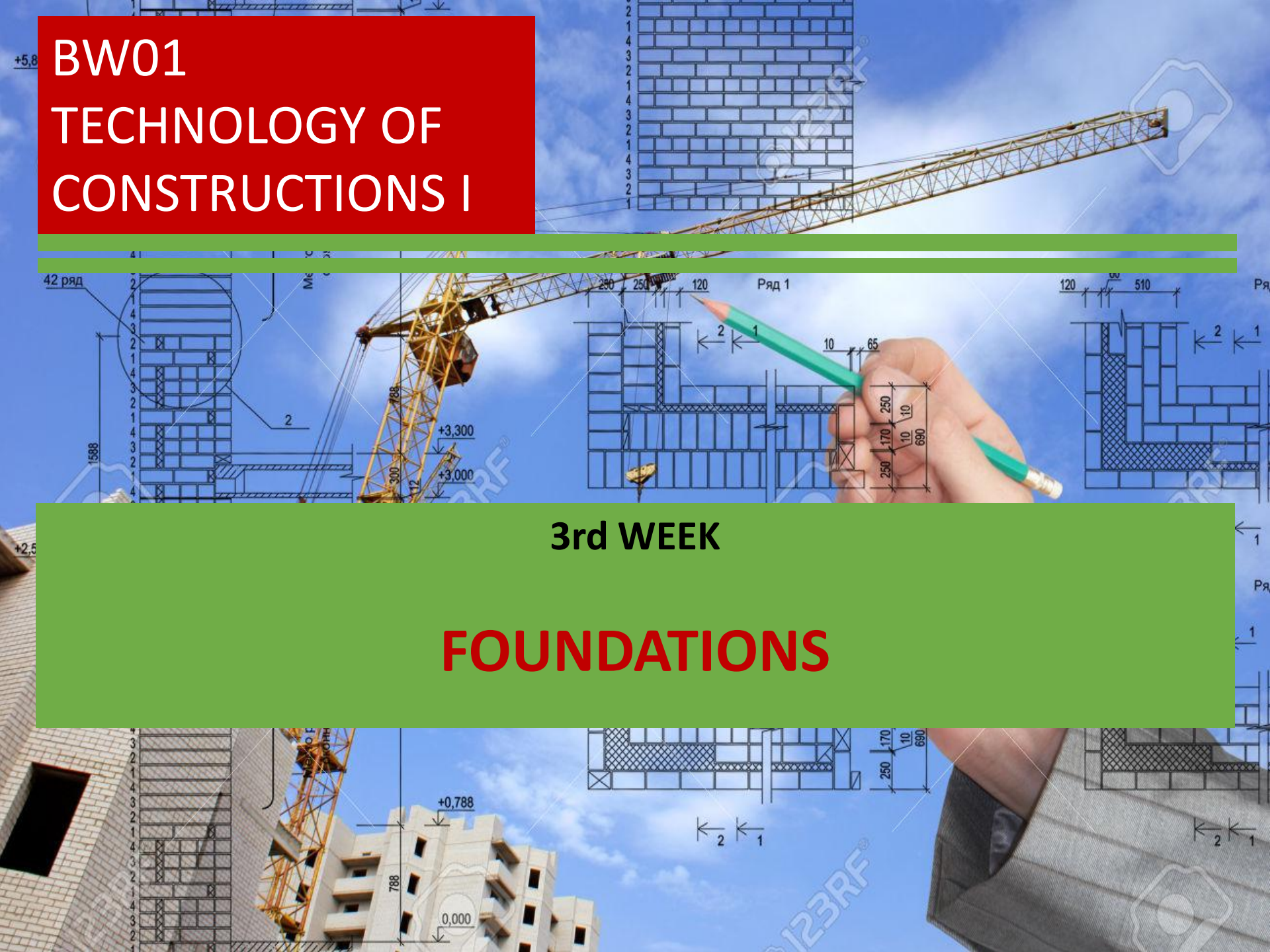
BW01
TECHNOLOGY OF CONSTRUCTIONS I



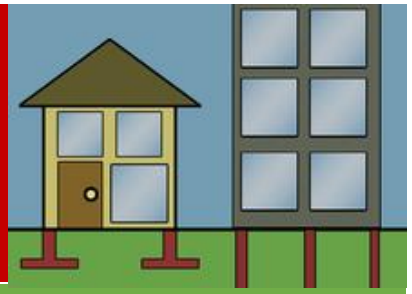
3rd WEEK

FOUNDATIONS

INTRODUCTION

- **WHAT IS THE FOUNDATION?**
- Definition:
  - Foundation is a structural part of a building on which a building stands.
  - Foundation transmits and distributes its own load and imposed loads to the soil in such a way that the load bearing capacity of the “foundation bed” is not exceeded.
  - The solid ground on which the foundation rest is called foundation bed.
  - We use various types of footing as a foundation.

INTRODUCTION



- A **foundation** is the element of an architectural structure which connects it to the ground, and transfers loads from the structure to the ground.
- Foundations are generally considered either shallow or deep.
- Foundation engineering is the application of **soil mechanics** and **rock mechanics** (Geotechnical engineering) in the design of foundation elements of structures.
- Foundations are designed to have an adequate load capacity depending on the type of subsoil supporting the foundation, and the footing itself may be designed structurally.
- The primary design concerns are **settlement** and **bearing capacity**.
- When considering settlement, total settlement and differential settlement is normally considered:
  - Differential settlement is when one part of a foundation settles more than another part.

HISTORIC FOUNDATION TYPES

- **Earthfast or post in ground construction**
  - Buildings and structures have a long history of being built with wood in contact with the ground.
  - Post in ground construction may technically have no foundation.
  - Timber pilings were used on soft or wet ground even below stone or masonry walls.
  - In marine construction and bridge building a crisscross of timbers or steel beams in concrete is called grillage.

- **Padstones**
  - Perhaps the simplest foundation is the padstone, a single stone which both spreads the weight on the ground and raises the timber off the ground.
  - Staddle stones are a specific type of padstone.

- **Stone foundations**
  - Dry stone and stones laid in mortar to build foundations are common in many parts of the world. Dry laid stone foundations may have been painted with mortar after construction.
  - Besides using mortar, stones can also be put in a gabion.
  - One disadvantage though of using a gabion is that if using regular steel rebars, the gabion would last less long than when using mortar (due to rusting). Using Weathering_steel rebars could reduce this disadvantage somewhat.

HISTORIC FOUNDATION TYPES

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- **Rubble trench foundations**
  - Rubble trench foundations are a shallow trench filled with rubble or stones.
  - These foundations extend below the frost line and may have a drain pipe which helps groundwater drain away.

LOADS ON FOUNDATION

- **Dead Load**
  - Refers to the overall weight of the structure. Includes weight of the materials permanently attached to the structure (such as flooring) and fixed service equipment (such as air conditioning)

- **Live load**
  - Refers to the weight of the applied bodied that are not permanent parts of the structure. Applied to the structure during part of its useful life (e.g. people, warehouse goods). Specified by code.

- **Wind loads**
  - Acts on all exposed parts of the structure. Calculated using building codes.

- **Earthquake Forces**
  - Building code is consulted.

FOUNDATION TYPES

- **Choosing a kind of foundation depends on:**
  - The ground conditions,
  - The groundwater conditions,
  - The site, the environment (the buildings nearby),
  - The strucutre of our building.

- **Requirements:**
  - Structural requirements:
    - Safety, be able to carry the load of the building, etc.
  - Constructional requirements:
    - Schedule, minimal resources, minimal cost, etc.

FOUNDATION TYPES

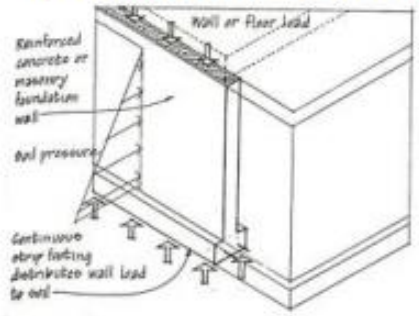
- **The specialities:**
  - it is expensive and difficult to repair
  - usually it is constructed under the ground, so it is out of sight
  - an bad/ misapplied foundation could demolish the building.
- **The mistakes:**
  - construction technology mistakes
  - bad or not proper technology (always necessary!!!)
  - planning mistakes: the type of foundation is inadequate for the ground layers / for the building

FOUNDATION TYPES

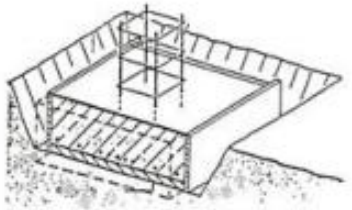
- **SHALLOW FOUNDATION**

about a meter or so into soil.
r pads of concrete (or other
ıt from walls and columns to

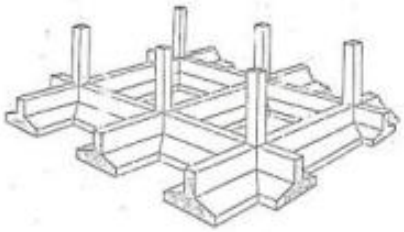
- **strip foundation (wall footing)**



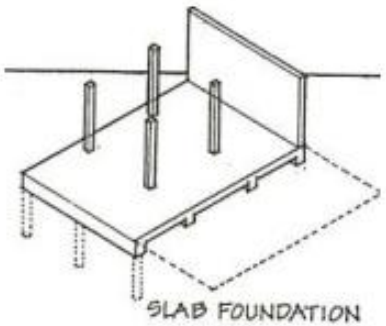
pad foundation



(beam) grillage foundation



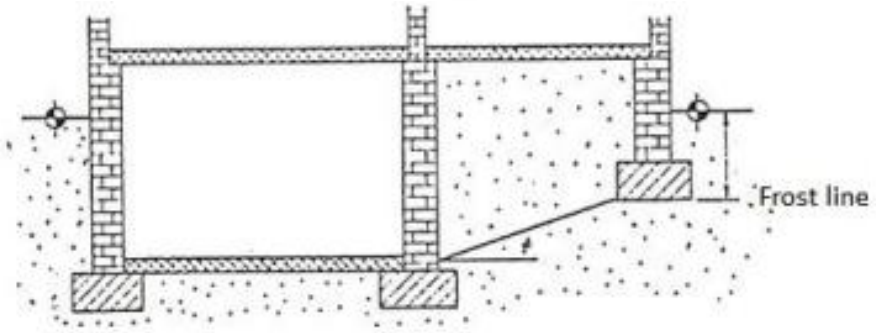
mat foundation

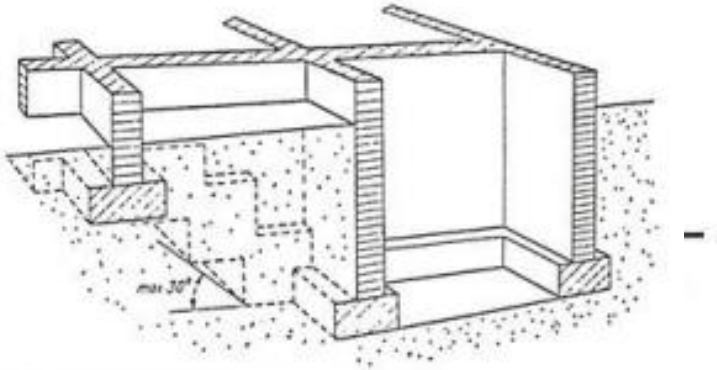


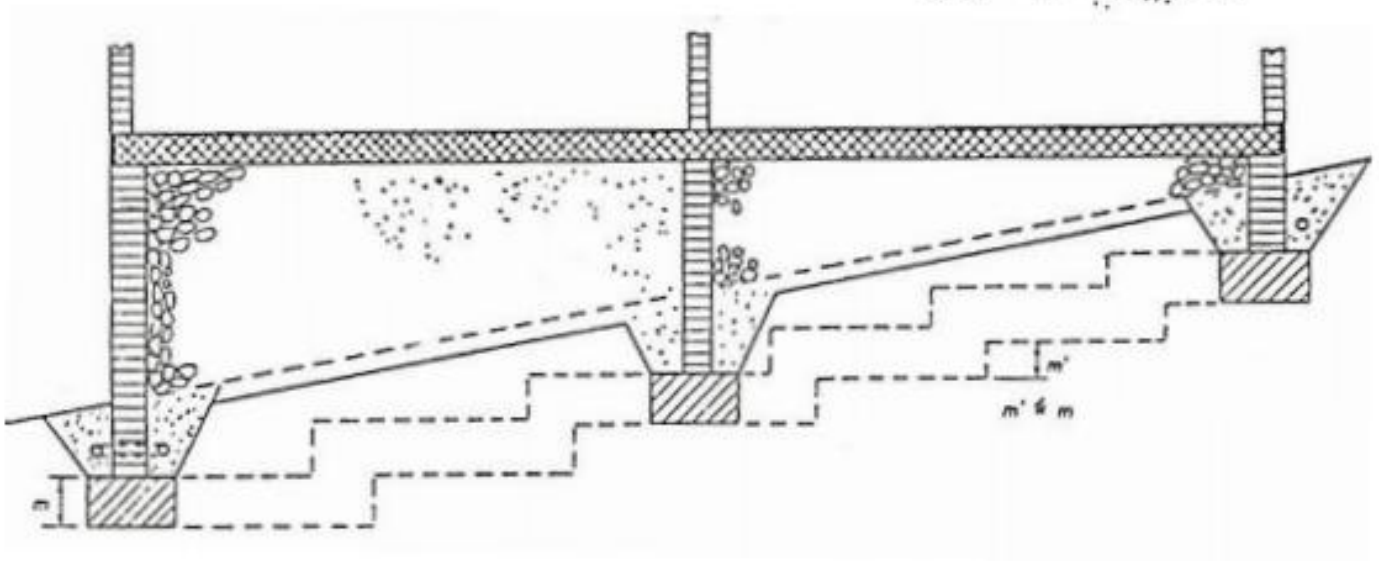
FOUNDATION TYPES

- **SPREAD FOOTING FOUNDATIONS**
  - Shallow foundations are also called spread footings or open footings. The 'open' refers to the fact that the foundations are made by first excavating all the earth till the bottom of the footing, and then constructing the footing.
  - During the early stages of work, the entire footing is visible to the eye, and is therefore called an open foundation.
  - The idea is that each footing takes the concentrated load of the column and spreads it out over a large area, so that the actual weight on the soil does not exceed the safe bearing capacity of the soil.
  - In cold climates, shallow foundations must be protected from freezing.
  - This is because water in the soil around the foundation can freeze and expand, thereby damaging the foundation.
  - **These foundations should be built below the *frost line*, which is the level in the ground above which freezing occurs.**
  - If they cannot be built below the frost line, they should be protected by insulation: normally a little heat from the building will permeate into the soil and prevent freezing.

FOUNDATION TYPES

- 





FOUNDATION TYPES

- **INDIVIDUAL FOOTINGS**
  - **Isolated footing**
    - These are most economical.
    - They are usually in square or rectangle size with the column sitting in the middle of the square.
    - It's a kind of pad footing.
  - **Combined footing**
    - A footing, either rectangular or trapezoidal, that supports two columns.
    - It's also a pad footing.
  - **Cantilever or strap footings**
    - Consist of two single footings connected with a beam or a strap and support two single columns.

FOUNDATION TYPES

- **SLAB – ON – GRADE FOUNDATION**
  - Slab-on-grade or floating slab foundations are a structural engineering practice whereby the concrete slab that is to serve as the foundation for the structure is formed from a mold set into the ground.
  - The concrete is then placed into the mold, leaving no space between the ground and the structure.
  - This type of construction is most often seen in warmer climates, where ground freezing and thawing is less of a concern and where there is no need for heat ducting underneath the floor.

FOUNDATION TYPES

- **SLAB – ON – GRADE FOUNDATION**
  - + The advantages of the slab technique are that it is cheap and sturdy,
  - + and is considered less vulnerable to termite infestation because there are no hollow spaces or wood channels leading from the ground to the structure (assuming wood siding, etc., is not carried all the way to the ground on the outer walls).

  - – The disadvantages are the lack of access from below for utility lines,
  - – the potential for large heat losses where ground temperatures fall significantly below the interior temperature, and a very low elevation that exposes the building to flood damage in even moderate rains.
  - – Remodeling or extending such a structure may also be more difficult.
  - – The slab can be decoupled from ground temperatures by insulation, with the concrete poured directly over insulation (for example extruded polystyrene foam panels), or heating provisions (such as hydronic heating) can be built into the slab (an expensive installation, with associated running expenses).

FOUNDATION TYPES

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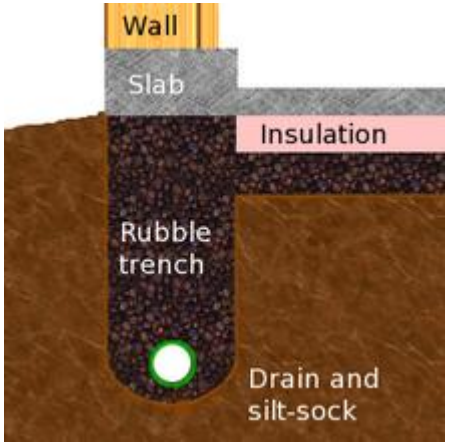
FOUNDATION TYPES

- **RUBBLE TRENCH FOUNDATION**
  - The rubble trench foundation, a construction approach popularized by architect Frank Lloyd Wright, is a type of foundation that uses loose stone or rubble to minimize the use of concrete and improve drainage.
  - It is considered more environmentally friendly than other types of foundation because cement manufacturing requires the use of enormous amounts of energy.
  - To construct a rubble trench foundation a narrow trench is dug down below the frost line. The bottom of the trench would ideally be gently sloped to an outlet. Drainage tile is then placed at the bottom of the trench in a bed of washed stone protected by filter fabric. The trench is then filled with either screened stone or recycled rubble. A steel-reinforced concrete beam is poured at the surface to provide ground clearance for the structure.
  - The rubble-trench foundation is a relatively simple, low-cost, and environmentally-friendly alternative to a conventional foundation, but may require an engineer's approval if building officials are not familiar with it.
  - Frank Lloyd Wright used them successfully for more than 50 years in the first half of the 20th century, and there is a revival of this style of foundation with the increased interest in green building.



FOUNDATION TYPES

- **EARTHBAG**
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  - his trench, nd form a
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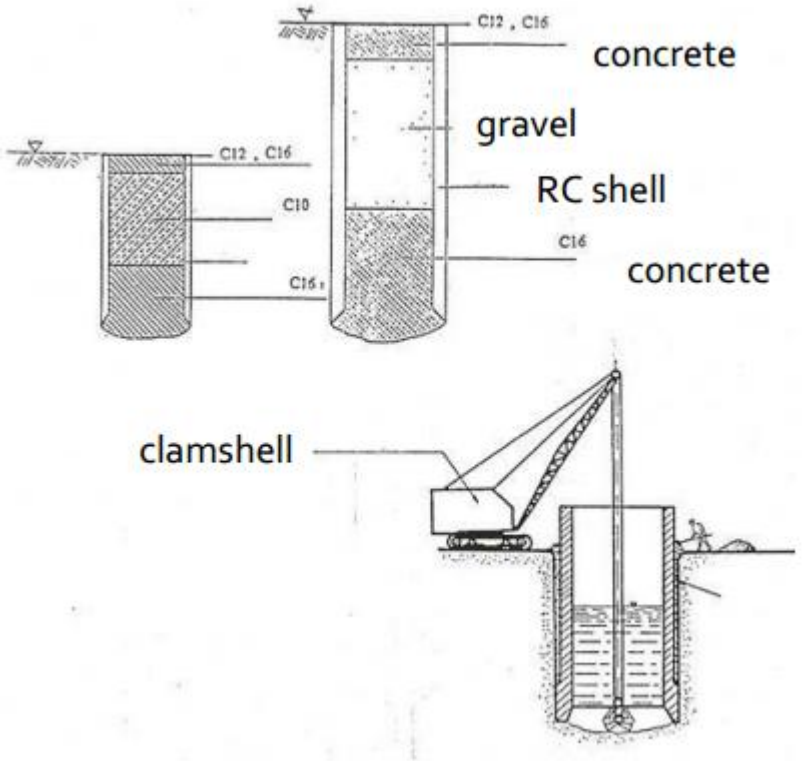
FOUNDATION TYPES

- **TRANSITIONAL (SEMI – DEEP) FOUNDATIONS**
  - Caisson
  - Cofferdam

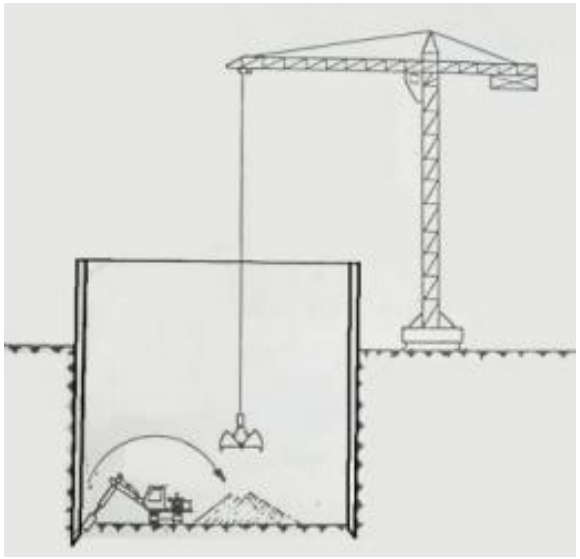
  - Caissons are a form of deep foundation which are constructed above ground level, then sunk to the required level by excavating or dredging material from within the caisson.
  - Large, open-ended compartments – shell or box with cutting edge at the bottom.
  - Sunk into the ground by digging the soil out of the centre and loading the walls.
  - Filled with concrete (and compacted gravel).

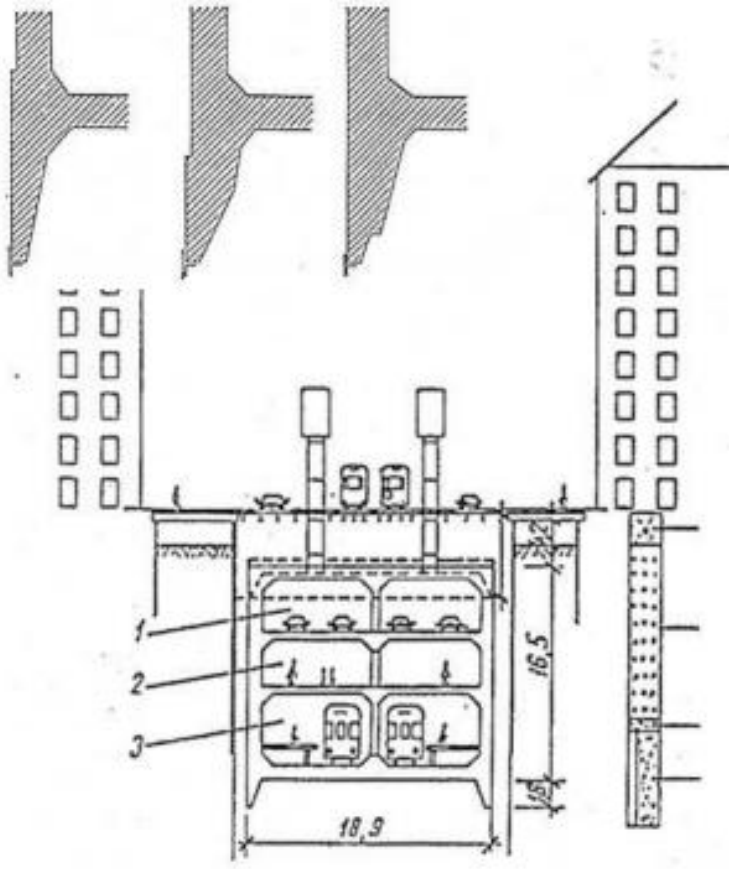


FOUNDATION TYPES

- **TRANSITIONAL (SEMI – DEEP) FOUNDATIONS**
  - Caisson
  - Cofferdam

  - Cutting edge types.
  - Creating an underground station.





FOUNDATION TYPES

- **DEEP FOUNDATION**
  - A **deep foundation** is a type of foundation which transfers building loads to the earth farther down from the surface than a shallow foundation does, to a subsurface layer or a range of depths.
  - A **pile** is a vertical structural element of a deep foundation, driven deep into the ground at the building site.

  - Types:
    - Drilled piles
    - Micropiles
    - Tripod piles
    - Sheet piles
    - Soldier piles
    - Suction piles
    - Adfreeze piles
    - Vibrated stone columns
    - Piled walls
    - Etc.

FOUNDATION TYPES

- **DEEP FOUNDATION**
  - There are many reasons a geotechnical engineer would recommend a deep foundation over a shallow foundation, but some of the common reasons are very large design loads, a poor soil at shallow depth, or site constraints (like property lines).
  - There are different terms used to describe different types of deep foundations including the pile (which is analogous to a pole), the pier (which is analogous to a column), drilled shafts, and caissons.
  - Piles are generally driven into the ground in situ; other deep foundations are typically put in place using excavation and drilling.
  - The naming conventions may vary between engineering disciplines and firms.
  - **Deep foundations can be made out of timber, steel, reinforced concrete or prestressed concrete.**

  - **Piers** are foundations for carrying a heavy structural load which is constructed in-situ in a deep excavation.
  - **Well foundations** are commonly used for transferring heavy loads to deep strata in river or sea bed for bridges, transmission towers and harbor structures.
  - **Piles** are relatively long, slender members that transmit foundation loads through soil strata of low bearing capacity to deeper soil or rock strata having a high bearing capacity.

FOUNDATION TYPES

- **DEEP FOUNDATION – METHODS OF INSTALLATION**
  - **DROPPING WEIGHT OR DROP HAMMER** is the most commonly used method of insertion of displacement piles.
  - **DIESEL HAMMER** produces controlled explosions which raises a ram used to drive the pile into the ground.
  - **VIBRATORY METHODS** can prove to be very effective in driving piles through non cohesive granular soils. The vibration of the pile excites the soil grains adjacent to the pile making the soil almost free flowing thus significantly reducing friction along the pile shaft.
  - **JACKING PILES** are the most commonly used methods in underpinning existing structures. By excavating underneath a structure short lengths of pile can be inserted and jacked into the ground using the underside of the existing structure as a reaction.

FOUNDATION TYPES

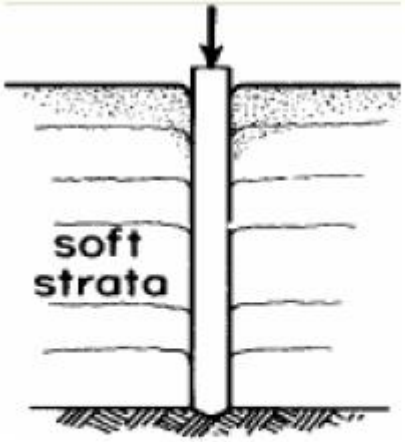


Fig.1: Point Bearing Files

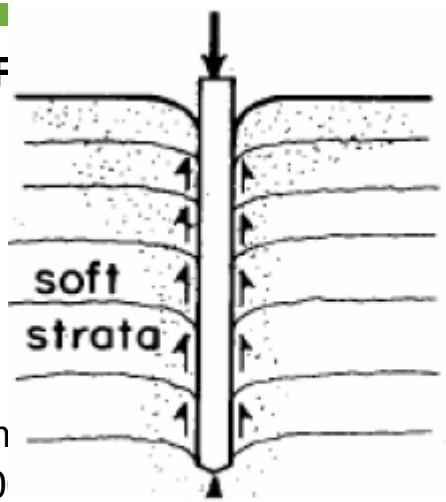


Fig.2: Friction Piles

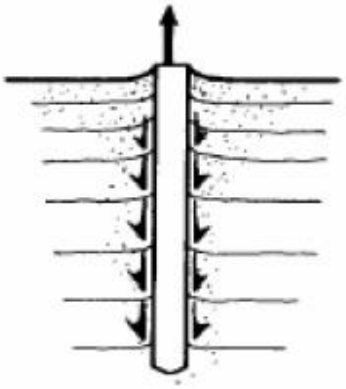


Fig.3: Uplift Piles

- **BASED ON LOAD TRANSFER MECHANISM**
  - End bearing piles.
  - Friction/Floating piles.
  - Bearing cum Friction piles.

FOUNDATION TYPES

- **DRIVEN FOUNDATION**
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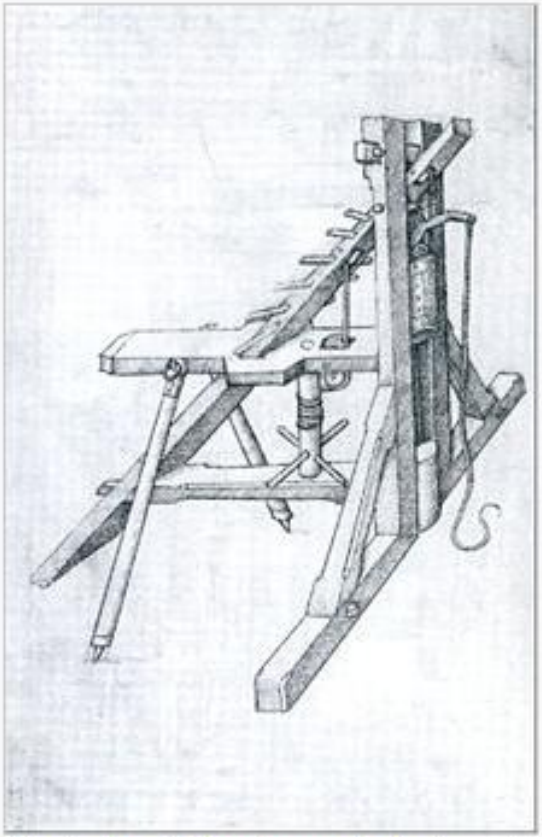


Illustration of a hand-operated pile driver in Germany after 1480.

FOUNDATION TYPES

- **DRIVEN FOUNDATION**
  - **Pile foundation system**
    - Foundations relying on driven piles often have groups of piles connected by a **pile cap** (a large concrete block into which the heads of the piles are embedded) to distribute loads which are larger than one pile can bear.
    - Pile caps and isolated piles are typically connected with grade beams to tie the foundation elements together; lighter structural elements bear on the grade beams, while heavier elements bear directly on the pile cap.
  - **Monopile foundation**
    - A monopile foundation utilizes a single, generally large-diameter, foundation structural element to support all the loads (weight, wind, etc.) of a large above-surface structure.

FOUNDATION TYPES

- **DRILLED PILES**
  - Also called **caissons**, **drilled shafts**, **drilled piers**, **Cast-in** **in-Situ** piles.
  - A borehole is drilled into the ground, then concrete placed into the borehole to form the pile.
  - Rotary boring techniques allow larger diameter piles th pile construction through particularly dense or hard stra
  - Construction methods depend on the geology of the si undertaken in 'dry' ground conditions or through water-
  - Casing is often used when the sides of the borehole ar poured.
  - For end-bearing piles, drilling continues until the bor (socketing) into a sufficiently strong layer. Depending or hardpan, or other dense, strong layers. Both the diame are highly specific to the ground conditions, loading co depths may vary substantially across a project if the bea

FOUNDATION TYPES

- **DRILLED PILES**
  - **Under-reamed piles**

  - Under-reamed piles have mechanically formed enlarged bases that are as much as 6 m in diameter.
  - The form is that of an inverted cone and can only be formed in stable soils.
  - The larger base diameter allows greater bearing capacity than a straight-shaft pile.
  - These pile are suited for expansive soils which are often subjected to seasonal moisture variations, as also filled up ground and loose or soft strata.
  - They are used in normal ground condition also where economics are favorable.

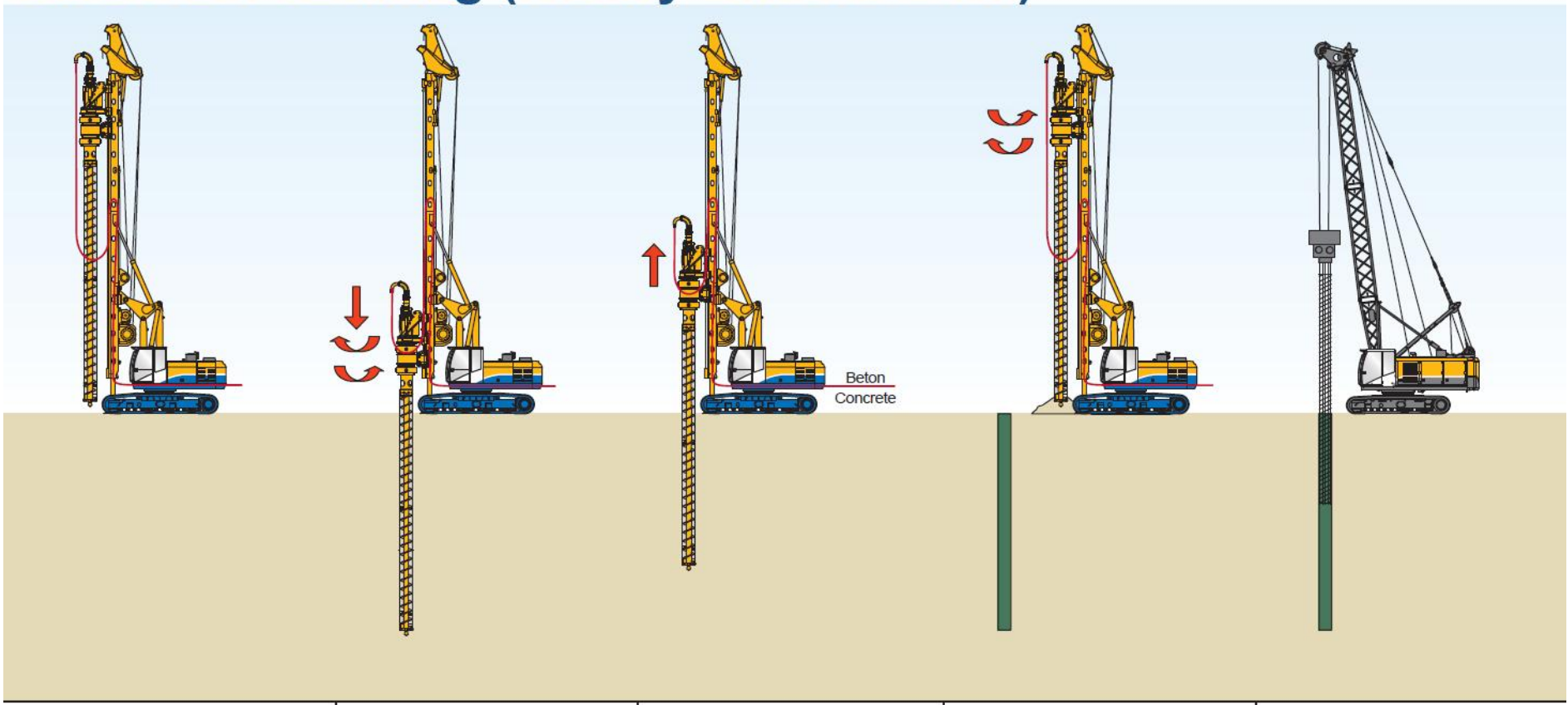
FOUNDATION TYPES

- **DRILLED PILES**
  - **Continuous flight augering (CFA) piles**

  - Is formed by drilling into the ground with a hollow stemmed continuous flight auger to the required depth or degree of resistance.
  - No casing is required.
  - A cement grout mix is then pumped down the stem of the auger.
  - While the cement grout is pumped, the auger is slowly withdrawn, conveying the soil upward along the flights.
  - A shaft of fluid cement grout is formed to ground level. Reinforcement can be installed.
  - Recent innovations in addition to stringent quality control allows reinforcing cages to be placed up to the full length of a pile when required. A typical reinforcing cage will consist of 4 to 8 bars from #5 to #8 bars typically 1/3 the length of the pile with longitudinal circular ties spaced along the length of the cage. Where tension loads are present it is typical to see a single full length bar placed at the center of each pile.

FOUNDATION TYPES

Cased CFA Drilling (Rotary Drive & BTM)



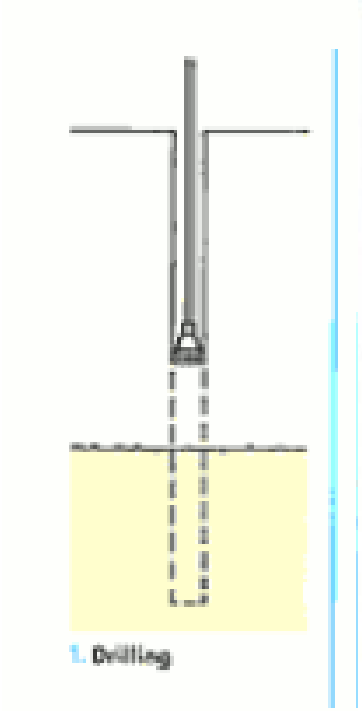
The cased CFA system consists of an upper standard rotary drive connected to the auger and a lower drive (BTM) connected to the casing and powered by the rotary drive.	**Rotate and push** the tools simultaneously into the soil. The soil is transported upwards along the flights and exits underneath the BTM into the soil chute.	**Concrete is pumped** through the hollow stem after reaching the final depth, while the auger and the casing are withdrawn.	Remove the rig from the borehole. Empty the soilfilled auger by changing the rotation direction of auger and casing.	**Push or vibrate the reinforcement cage** into the freshly poured pile.

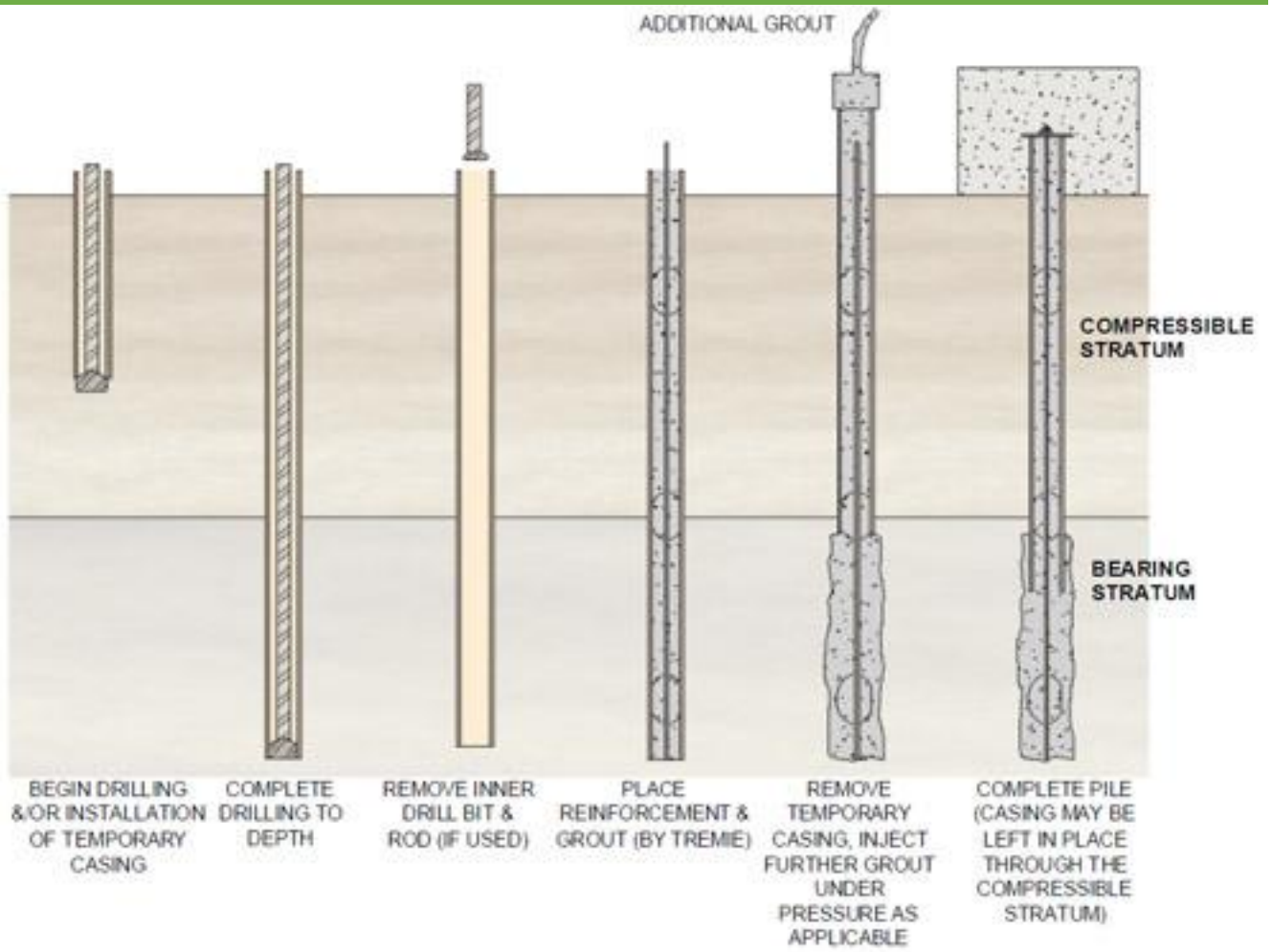
FOUNDATION TYPES

- **DRILLED PILES**
  - **Pier and grade beam foundation**
  - In drilled pier foundations, the piers can be connected with grade beams on which the structure sits, sometimes with heavy column loads bearing directly on the piers.
  - In some residential construction, the piers are extended above the ground level and wood beams bearing on the piers are used to support the structure.
  - This type of foundation results in a **crawl space** underneath the building in which wiring and duct work can be laid during construction or re-modelling.

FOUNDATION TYPES

- **SPECIAL PILES**
  - **Micropiles**





FOUNDATION TYPES

- **SPECIAL PILES**
  - **Sheet piles**
  - Sheet piling is a form of driven piling using thin interlocking sheets of steel to obtain a continuous barrier in the ground.
  - The main application of sheet piles is in retaining walls and cofferdams erected to enable permanent works to proceed.
  - Normally, vibrating hammer, t-crane and crawle drilling are used to establish sheet piles.

FOUNDATION TYPES

- **SPECIAL PILES**
  - **Soldier piles**

- Soldier piles, wide flange steel H sections spac
- As the excav d behind the H pile flanges.
- The horizont use of their relative rigidity comp
- Soil moveme rm contact with the soil.

+ Soldier piles s will not result in subsidence s if they have some cohesion, an ds.
– Unsuitable so movements such as loose sands. the excavation and dewatering is

FOUNDATION TYPES

- **SPECIAL PILES**
  - **Suction piles**
  - Suction piles are used under water to secure floating platforms.
  - Tubular piles are driven into the seabed (or more commonly dropped a few meters into a soft seabed) and then a pump sucks water out at the top of the tubular, pulling the pile further down.

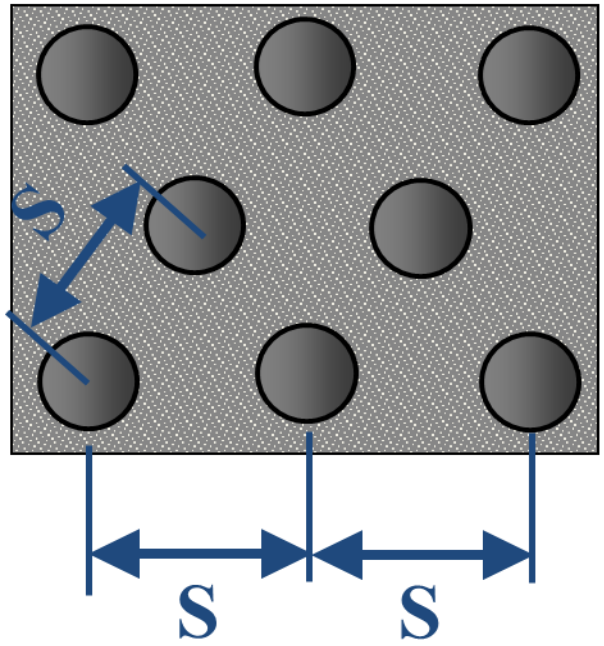
  - **Adfreeze piles**
  - In high latitudes where the ground is continuously frozen, adfreeze piles are used as the primary structural foundation method.
  - Adfreeze piles derive their strength from the bond of the frozen ground around them to the surface of the pile.
  - Adfreeze pile foundations are particularly sensitive in conditions which cause the permafrost to melt. If a building is constructed improperly, it will heat the ground below resulting in a failure of the foundation system.

FOUNDATION TYPES

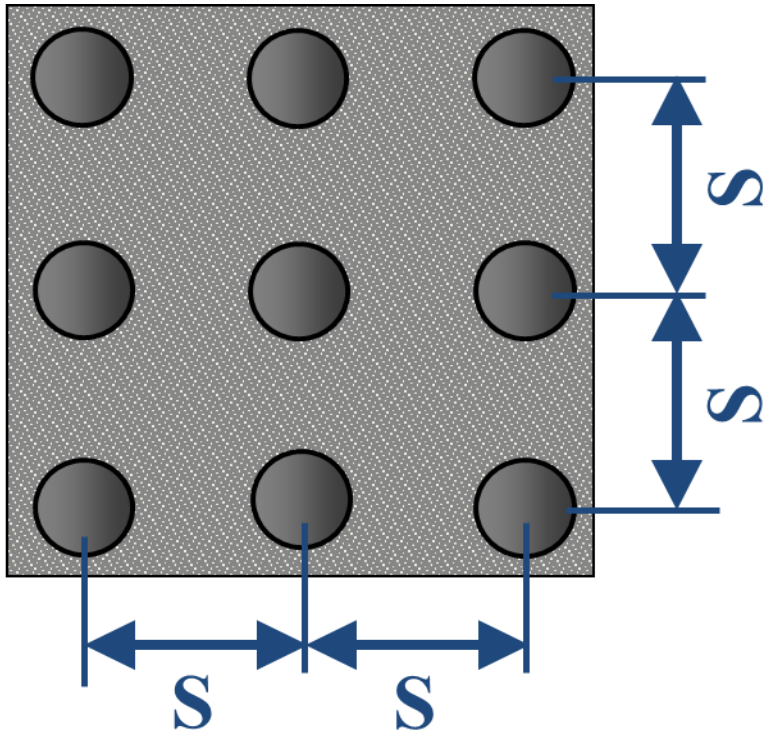
- **SPECIAL PILES**
  - **Vibrated stone columns**
  - Vibrated stone columns are a ground improvement technique where columns of coarse aggregate ("stone") are placed in soils with poor drainage or bearing capacity to improve the soils.

FOUNDATION TYPES

PILE SPACING



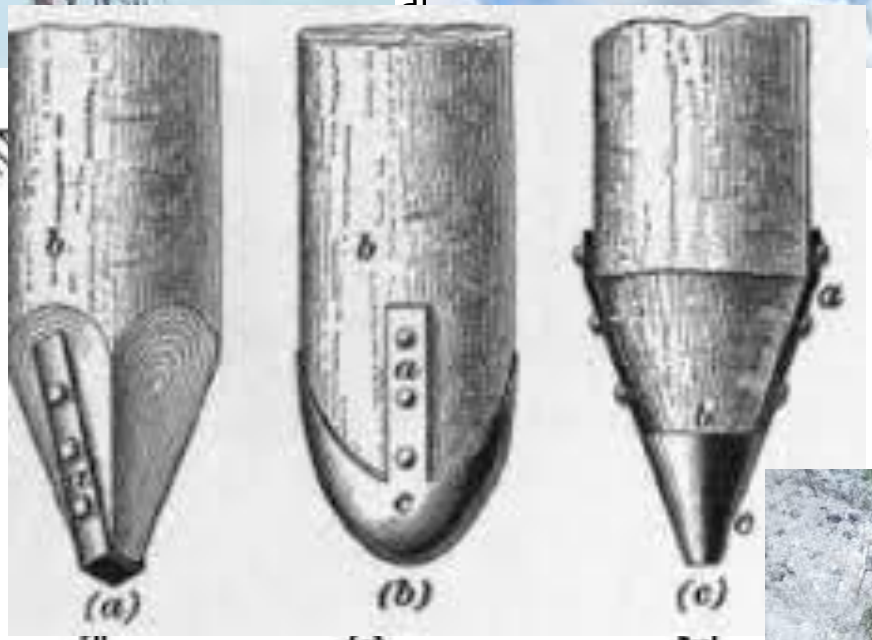
8 Piles



9 Piles

MATERIAL

- **TIMBER**



- May require tr
- Easily damage

MATERIAL

- **STEEL**
  - Pipe piles are a type of steel driven pile foundation and are a good candidate for inclined (battered) piles.
  - Pipe piles can be driven either open end or closed end.
  - When driven open end, soil is allowed to enter the bottom of the pipe or tube. If an empty pipe is required, a jet of water or an auger can be used to remove the soil inside following driving.
  - Closed end pipe piles are constructed by covering the bottom of the pile with a steel plate or cast steel shoe.
  - In some cases, pipe piles are filled with concrete to provide additional moment capacity or corrosion resistance.
  - The structural capacity of pipe piles is primarily calculated based on steel strength and concrete strength (if filled).
  - Steel pipe piles can either be new steel manufactured specifically for the piling industry or reclaimed steel tubular casing previously used for other purposes such as oil and gas exploration.
  - H-Piles are structural beams that are driven in the ground for deep foundation application. They can be easily cut off or joined by welding or mechanical drive-fit splicers. If the pile is driven into a soil with low pH value, then there is a risk of corrosion

MATERIAL

- **STEEL**

MATERIAL

- **CONCRETE**
  - **Prestressed concrete piles**
  - Concrete piles are typically made with steel reinforcing and prestressing tendons to obtain the tensile strength required, to survive handling and driving, and to provide sufficient bending resistance.
  - Long piles can be difficult to handle and transport. Pile joints can be used to join two or more short piles to form one long pile.
  - Pile joints can be used with both precast and prestressed concrete piles.

  - **Composite piles**
  - A "composite pile" is a pile made of steel and concrete members that are fastened together, end to end, to form a single pile.
  - It is a combination of different materials or different shaped materials such as pipe and H-beams or steel and concrete.

MATERIAL

- **CONCRETE**

THANK YOU FOR YOUR ATTENTION

THAT‘S ALL FOLKS ☺